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SIR J. NORMAN LOCKYER, K.C.B., F.R.S.

BY JOHN SATTERLY

Born in 1836 at Rugby the subject of this memoir was educated at private schools in England. Following a normal course of instruction at home and on the continent, he entered in 1857 the administrative side of the War Office. He found favour with the authorities and in 1865 he was given the important task of editing the Army Regulations. We can imagine, however, that routine work did not call for all the energy of young Lockyer and he turned to Astronomy as a hobby. After passing through the various phases of the observational work of the beginner in astronomy he felt his call to spectroscopy and the study of solar physics.

His first great achievement in spectroscopy was the observation of the bright lines in the spectrum of the chromosphere without having to wait for a total solar eclipse to obliterate the effect of the photosphere. This occurred in 1868, and in 1871 he pushed the analysis further by the discovery of a bright yellow line in the spectrum not far away from the double sodium line. This line did not belong to any known terrestrial element and Lockyer christened it the *helium* line from the Greek *helios*, the sun. In 1895, fully 24 years after Lockyer's discovery, Sir William Ramsay discovered helium as an occluded gas in the mineral cleveite and we know now that millions of cubic feet of helium gas escape from the earth every day with the natural gas found so abundantly in Canada and the United States. The discovery of helium by Lockyer in England coincided with Janssen's identical discovery in France, and for this work they were given a joint medal by the Paris Academy of Science.

The Royal Society of London bestowed its fellowship on Lockyer in 1869. This must have been a busy time for Lockyer for in the same year he founded the English scientific weekly "Nature," now known and admired all the world over for its

SIR J. NORMAN LOCKYER, K.C.B., F.R.S.
(From a group photograph taken in 1900)

accurate scientific information in the form of articles, notes, book reviews, letters and its well-known astronomical column. The influence of "Nature" on scientific progress, not only in England but also abroad, has been enormous and we must admire the

genius of young Lockyer in its foundation, and the mode in which he managed and edited it for fifty years.

In 1870 he was appointed to the Royal Commission on Scientific Instruction and the Advancement of Science. The reports of this commission kept science to the front and pushed science teaching into the schools and colleges of England. Lockyer was often impatient at the slowness with which the British public realized the importance of scientific ideas and how it was largely oblivious to the scientific revolution which filled the second half of the nineteenth century.

Among other honours which fell to him at this time were, in 1874, the Bakerian lectureship and the Rumford medal of the Royal Society, and in 1875 a corresponding membership of the Paris Academy.

On the close of the work of the Royal Commission in 1875 Lockyer was transferred to the Science and Art Department at South Kensington, a large residential quarter in S.W. London, where the English Government had established (upon the advice of the Prince Consort) a large scientific museum built up from exhibits and funds which accrued from the Great Exhibition of 1851. In the grounds of the South Kensington Museum the Government established the offices of the Science and Art Department, which helped on and in many ways controlled the teaching in science and art of the municipal and other secondary schools of Great Britain.

The Royal College of Science was established also in the same grounds by the advice of the same master as a training school for science teachers. It has served as a land mark in South Kensington for many years. This college has had many important educators on its staff; foremost amongst these was Huxley. The aim of the college instruction was to train up scientific observers and teachers, chiefly among the middle classes of England, and to send these out as pioneers into the middle class schools to awaken the enthusiasm of the boys for natural and experimental sciences. There being a great dislike on the part of the British public to raise any money for education, it was a part of the policy of the Science and Art Department to train its students to make their own apparatus and thus be able to start school laboratories without much expense to the country.

Norman Lockyer was made Professor of Astro-Physics here in 1875, and in conjunction with his teaching work in the college he established the South Kensington Observatory in plain domes and tin huts, which were long looked upon as out of place in highly delectable South Kensington. He was now more at liberty to develop his ideas on the spectroscopy of the sun and the stars, and one of the features of the South Kensington observatory was the dual nature of the work, a physics laboratory working in conjunction with an observatory. This is common enough now, but it was the genius of Lockyer which saw that in order to interpret aright the spectra of the heavenly bodies it was necessary to have a laboratory in which one could treat the gases and metals to high temperatures and pressures and electric discharges of all kinds and to try to imitate the conditions which exist in the sun, stars, nebulae and other heavenly bodies. In this work Lockyer was ably assisted by Fowler, Butler, Baxandall, Shackleton, Rolston, and his son, W. J. S. Lockyer, and their joint results loom large in the history of astrophysics. At the same time Lockyer developed the course of Astrophysics in the Royal College of Science, a joint course of observatory, laboratory and lectures which I shall describe more fully later on.

Lockyer's great work was, of course, on the sun. He was the leader of eight of the English solar eclipse expeditions, and when in 1885 the observatory was named the Solar Physics Observatory Lockyer was created director. Jumping over the years and referring the reader to the fuller accounts of Lockyer's astronomical discoveries which have appeared in "Nature," "The Observatory" and in the publications of some of the astronomical societies, we may mention that Lockyer was knighted by Queen Victoria in 1897 and elected President of the British Association for the Advancement of Science at its Southport meeting in 1903. On the occasion of his presidential address Sir Norman gave a noteworthy account of "The Influence of Brain-power on History." The chief English newspapers always give plenty of space to the Presidential and other addresses of the Association, and Lockyer had now a chance of appealing to a larger audience than usual. His address gave an immense impetus to the advancement of scientific thought and work amongst the people and one immediate

effect was a large increase in the Government grant for scientific research work in the universities. To further his ideas he founded the British Science Guild in 1905 on a more democratic basis of membership and activity than was possible with the British Association, and here he and his friends advocated the advance of science on all occasions and endeavoured to awaken the Government to the needs of the times. The work of the British Science Guild bore much fruit during the stirring times of the late war.

In 1912-13 the British Government decided to abolish the South Kensington Observatory and to transport the apparatus and staff to the newly created solar physics department of the Observatory of the University of Cambridge. Possibly the Cambridge atmosphere is better for the work but thousands of Londoners missed, and will miss, the sight of a working observatory, and often it is true that what the casual observer does not see he loses interest in and is not prepared to spend money on. This change was a great blow to the Director. His work at South Kensington ceased, but he transferred his activities to the little observatory on the hill top at Salcombe Regis, near Sidmouth, on the sunny Devon coast. Here with the help of discerning friends he started anew to build up an observatory with all its various paraphernalia of telescopes and laboratory appliances. His pioneering ability and genius to provoke the aid of others soon established the Hill Observatory Corporation, which placed the observatory on a permanent basis, and before long bulletins of astronomical progress announced that Sir Norman was still as active as ever.

The end, however, was drawing near. Like a rocket which bursts into a brilliant display just before its departure from sight, the editor issued in November of 1919 the jubilee number of "Nature." It is a wonderful record, the magazine during those fifty years running on week after week, practically unaltered in form from the beginning, so great was Lockyer's insight at that early time into the scientific needs of England. The jubilee number contains a portrait and an account of Lockyer's work contributed by Deslandres of Paris. The portrait shows Sir Norman in a deck chair sitting in the sun at Sidmouth. It also contains most valuable summaries by the English scientific worthies of the advancement of their own particular lines of work during the first fifty

years of "Nature," and succeeding numbers contained appreciations of Sir Norman Lockyer's weekly journal from scientists and societies all the world over.

Sir Norman now retired from the editorship, and after a brief nine months of rest, he died in August, 1920. His body is buried in the little churchyard near the observatory, his last monument to his scientific activities. May others be inspired to continue his work!

Sir Norman Lockyer was a pioneer. He had ideas ahead of his time and was not afraid to push them. In particular he had unique ideas on cosmic evolution and archaeology. He published books on "The Chemistry of the Sun" (1887), "The Meteoritic Hypothesis" (1890), and "Inorganic Evolution" (1900), in which he endeavoured to show stellar evolution from relatively cold nebulae up to very hot stars and then down the temperature scale to older and colder stars. Some of his opinions in this work are closely related to the modern views on transmutation of elements brought about by radioactivity and atomic disintegration. His archaeological researches consisted of the application of astronomy, and in particular of the precession of the equinoxes, to determine the dates at which some of the earlier civilizations thrived. He endeavoured to get at the dates of the constructions of Stonehenge, the Egyptian Pyramids, some Greek Temples, of many of the stone circles and avenues of the South of England, the North of Scotland, and of Brittany, working from their orientations with respect to the cardinal points of the compass and the supposed bright star which would rise above the horizon along certain alignments from these temples. His work on this line was highly original, extremely interesting and provoking of much other work on our ancient monuments.

The Editor of the JOURNAL has asked me, as an old student of the Royal College of Science, to say something of the course in Astronomy at South Kensington. I am glad to be able to give here my testimony to Sir Norman Lockyer, because I think that in my after-college days I have derived more pleasure from the application of my small knowledge of astronomy than I have from any other part of my studies. In order to make my description clear I must

first of all say that in many ways the courses of studies at South Kensington were very differently arranged from those at the University of Toronto. For one thing the college was definitely scientific. Granted that a student had a good general education, at the age of eighteen years he was trusted to keep himself up on the general knowledge side and no attempt was made to burden him with pass courses in various fields of knowledge, such as are studied indifferently by honour students in Toronto. The arrangement of the course of instruction was simple, so simple that only once in my three years there did I have occasion to enter the registrar's office.

In the first year all the students did chemistry for the first four months and physics for the second four months, between four and five hours a day. Mathematics, of standard according to ability, took about four hours a week, and this ran all the year. Astronomical Physics ran also all the year with a fortnight's intensive work at the end of the session.

Sir Norman Lockyer arranged the astro-physical course in this wise. A very carefully prepared handbook of observational and laboratory work was prepared by him as a student's guide. The whole body of first year students—about one hundred in number—were divided into six classes and these went to the observatory once a fortnight for two hours' work. In the first hour Professor Fowler lectured on descriptive astronomy, thus preparing the way for the practical astronomy that was to follow. In these practical classes in the observatory we made the acquaintance of the instruments in the observatory, including the transit instrument, the 10-in. refractor, the 6-in. refractor and so on.

One can realize what it meant to those of us who were keen science students to have the run of an observatory such as this and to see the expert astronomers engaged in the development of their subject. I have my notebook by me now and turning over the pages I see that we mastered the problems of elementary descriptive astronomy, that we used the chronograph for time signals and transits, practised the setting of the equatorial telescopes on the planets and stars, used the altazimuth, learnt how to use various kinds of micrometer eyepieces, the wedge photometer on star magnitudes, and the McClean spectroscope on the stars.

In the June practical classes we spent a fortnight, with two whole days (about five hours a day) at a time on the following: (1) Use of the globes (including the precessional globe); (2) making an astronomical telescope (from cardboard, cartridge paper and glue, the objective being a $2\frac{1}{2}''$ achromatic and a Ramsden eyepiece of lenses of $3''$ and $1''$ focal length); (3) use of the plane-table, theodolite and prismatic compasses for surveying the grounds of the observatory, and of the theodolite and sextant for altitude and size measurements, and the magnetic dip with the dip circle; (4) use of the spectroscope on the metallic lines, and on absorption spectra; (5) photographing arc and spark spectra of the metals and gases and measuring up spectra; (6) making a graphic study of eclipses, planetary paths, sunspot cycles and calculations of current astronomical events from the Nautical Almanac, a copy of the current year being presented to each student. Stress was laid in all cases on accurate draughtmanship.

During this June course Sir Norman Lockyer delivered one lecture a day. These lectures (twelve in number) were copiously illustrated with diagrams and I well remember how some of us made a point of copying out most of the charts. Sir Norman was an ideal lecturer and quite at ease with the students. The lectures dealt with the components of the Solar System, with applications of Kepler's Law and Newton's Law of Gravitation, and the theory of tides. Spectroscopy followed and the rest of the lectures practically dealt with the application of the spectroscope to the study of the solar universe in which subject Lockyer of course spoke as a master. Elementary mathematical astronomy was thus left on one side, it having been already dealt with by Professor Fowler. The varieties of spectra were dealt with, then their elucidation, with the theories of common and absorption spectra, sharp lines, enhanced lines and flutings, followed by a consideration of the application of the Doppler effect. The physics of the sun was taken up in detail with the different spectroscopic methods of studying the solar surface both at eclipse times and ordinary times. Sunspots and the sunspot cycle and a general treatment of solar radiation followed. The spectroscope was then applied to the other members of the solar system, the planets (including the rings of Saturn), meteorites and comets. Stars and nebulae were next treated

with their physical constitution and distribution. Stellar spectra were classified, temperature curves drawn and the evidence of stellar evolution built up, with a conclusion leading to Lockyer's meteoritic hypothesis. New stars were then treated, their colours, spectra, and their distribution in space with theories as to their probable production. Series of lines in spectra were considered in some detail followed by a summary of what was known at the time of the evolution of the chemical elements. There followed a short account of atmospheric temperatures and circulation and a consideration of the atmospheric composition and circulation of the planets.

It was my fortune to be a student in the year 1898-1899 and to demonstrate in the fortnight's session of 1900, and I well remember Sir Norman's periodical visits around to the work rooms to stimulate everybody by the interest he took in the subject.

It will thus be seen that in the first year course of Astronomical Physics at the Royal College of Science, Sir Norman Lockyer built up on a strong foundation of observatory and laboratory work a knowledge of solar and stellar astrophysics which served to open up the eyes of *all* students to the broad problems of celestial evolution and atomic structure.

Not only was the Royal College of Science available for the ordinary student but every year there was a summer session of about three weeks when teachers came from all parts of the British Isles to London to brush up their sciences and renew their acquaintance with the treasures kept in the museums of London. The summer session in Astronomical Physics came every other year. These classes were smaller than the regular classes so that more individual attention was possible. The visiting teachers had the usual round of work as described above, but in addition to making the astronomical telescope, made also a simple Hadley's sextant for themselves, so that they could repeat their observations when they returned to their homes. Those who were very interested were also instructed how to make a simple wooden equatorial mounting for the telescope mentioned above.

It was my privilege to demonstrate in the observatory and handle the telescopes in the summer of 1900 and here we observed sunspots every day (weather permitting), measured their positions

and rotation, measured the solar and lunar diameters, and used the micrometer and position circles for measuring stellar distances and directions. (As much of the work was done in the day, church spires, museum towers and chimney pots had to serve as celestial objects). My notebook records, however, that we used Cooke's Filar micrometer for measuring the diameter of Jupiter and of Saturn's Rings. The latitude of South Kensington was measured with the sextant both from the stars and the sun.

I have tried above to give a description of the teaching in Astronomy done under Sir Norman Lockyer's direction in one college in London. What has been done at one place can be done in another if the means are available. All the first year science students took this course whatever their specialization in the following years. Astronomy is the Queen of the Sciences; the history of Astronomy is the history of Mathematics, both pure and applied, and also in as large measure the history of Physics. I am sure that all the students benefited by such a course. No matter whether or not they will ever read up any more astronomy, the sky and the celestial bodies therein would have a different meaning and value to them afterwards than they ever had before. It would be a good thing if in all universities the Honour students (whatever their subject) were given the privilege of making astronomical observations and carrying out laboratory work on astrophysics. It need not be all taken in the first year. The arrangements already in existence, at Toronto for example, might make it preferable to leave the astrophysics to the third year. But in my opinion it is a great mistake to pass students through an Honour course in Science without fulfilling the desire which must come at times to every science student to know something of the sun, moon, the planets and the wide world beyond the solar system. This applies especially to students in a country of clear skies like Canada when on a cold winter's night the sky seems to be ablaze with stars. He must be a dull man indeed who does not feel the call to probe their secrets. This call Sir Norman Lockyer attempted to satisfy, and I for one am always grateful that it was my privilege to take such a course. It has cheered me and given me a sense of comradeship on many a night since my student days.

The Leonids were due to visit the earth in November 1899, and there was a great talk in the newspapers of the wonderful sight that the Leonids made in 1866. Sir Norman Lockyer kindly consented to address the students on the Leonids at lunch time on November 14th (I believe), and at 1.30 p.m. the Chemical Lecture theatre was packed with a lively crowd of London students. Sir Norman Lockyer entered the theatre in the middle of this pandemonium and some of the students struck up some popular song with the idea, I suppose, of postponing the more serious talk, but Sir Norman seized the opportunity at once and stepping to the middle of the lecture bench he beat time with both hands and conducted the music with such a look of beaming cheerfulness and comradeship that the students realized his graciousness and stopped at the end of the next verse. After that he had as quiet an audience one could wish and at the close of the talk we all joined in "For he's a jolly good fellow".

When the Solar Physics Observatory was removed to Cambridge, Sir Norman Lockyer departed from the Royal College of Science. The new buildings of the Royal College of Science which were erected about 1908 have however special laboratory equipment for the study of astrophysics; in fact very few colleges are so superbly provided for accurate work on this line. Professor Alfred Fowler, Sir Norman's lieutenant, has now charge of this laboratory and those who have followed the brilliant work of Fowler on spectra in the last fifteen years know that the story begun at South Kensington by Lockyer is still being continued by able hands and eyes.

A contemporary of Lockyer's has also recently passed away. Sir William Abney, K.C.B., F.R.S., known to many for his work on the spectrum, on photography and on the measurement of colour was also an officer in the Science and Art Department and a Lecturer in the Royal College of Science. He had his own private laboratory in the Museum's grounds and there he worked for many years. One of his achievements was the photography of a kettle containing boiling water in a perfectly dark room. This was made possible by his invention of a photographic plate which is sensitive to the dark heat rays (the infra-red rays). Sir William Abney

lectured to the third year physics students on colour measurement and mixture and as I am colour-blind Abney used me as an example, in the matching of colours, to the class on more than one occasion, greatly to the delight of the other students who thought I was "pulling Abney's leg" until he showed them that it was impossible for him to be tricked. He afterwards tested me in his own laboratory and proved to his own satisfaction that I was fully red-blind and that a certain portion of the spectrum, somewhere near the greenish-blue appeared to me indistinguishable from white.

UNIVERSITY OF TORONTO.

NOTE ON THE EMISSION BAND AT Hβ IN NOVA AQUILAE NO. 3

By W. E. Harper

In the December 1918 issue of this Journal the writer gave a summary of the emission spectrum of Nova Aquilae No. 3 wherein he found the emission at Hβ to be about 54 A in width with its centre displaced about 1 A to the violet of its normal position. This was based on 28 plates taken at Ottawa between July 19th and November 10th, 1918, the plates earlier than these indicating a displacement of 0.4 A but with limits poorly determined. Had these earlier plates been included the mean displacement would have been in the neighbourhood of 0.8 A. Though the positions of the other bands were more or less roughly measured, this was the only one whose limits seemed sufficiently definite to base any conclusions upon.

In the case of Nova Aurigae 1892, while the literature on the subject is often contradictory, the results of Campbell, whose authority seems the best, showed that the emission bands were displaced to the violet 4 or 5 A, though at times they were recorded much nearer their normal positions. But in recent cases, such as Nova Persei 1901 and Nova Geminorum 1912, where it is only natural to expect more accurate determinations, the emission bands were about 1A to the red in each case. This circumstance of a negative displacement in Nova Aquilae seemed to impress itself on the writer, and on coming to Victoria a few preliminary measures were made on the plates here with somewhat similar results.

Adams finds corroboration of this violet displacement on the Mount Wilson plates, as recorded in *Astrophysical Journal* for March 1920, page 126. Lunt discusses the emission spectrum at some length in *Monthly Notices* for March 1920, and gives results for the 3 hydrogen bands β, γ and δ as well as for the nebular bands N_1 and N_2. He finds an average displacement represented by -51.6 km per sec., the equivalent at Hβ of 0.84 A to the violet. His displacement at Hβ alone is 0.94 A, but this is not comparable

to my result because of a correction which I made—and which Dr. Lunt preferred not to make—namely, that required for the 20 km per sec. approach as adduced from the sharp H and K lines. The consensus of opinion among astronomers, I believe, has been to regard these very fine sharp calcium lines as reversals indicating the true velocity of the star. On such an assumption a correction of +0.31 A would be required to Lunt's displacement making it 0.63 A. Lunt considers this view erroneous and looks upon the broad emission bands as giving the true velocity of the nova, namely −51.6 km per sec.

The purpose of this article is, however, not to discuss this phase of the question but to give the results of additional measures. Looking over Lunt's results I began to wonder if I had been too hasty in considering that no reliance could be placed on measures of the other bands. To that end I have examined many of the Victoria plates and 41 plates taken at Ottawa between July 1st and November 30th, which the Director, Dr. Klotz, was kind enough to send me, and I have not felt like changing my former opinion that measures made upon the other bands are only rough approximations at best. True, the nebular lines are occasionally definite, but the comparison lines are not always of the best. In the early stages Hγ is sharply defined by the absorption line at its violet edge and fades off very gradually into the continuous spectrum at its red edge and later it becomes blended with the nebular band λ4363 so that uncertainty prevails in either case. However occasion has been taken to measure Hβ again on the 41 Ottawa plates and on 20 Victoria plates as well, covering practically the same interval with the following result.

20 Victoria plates	λ4860.420
41 Ottawa plates	4860.466

The weighted mean, when correction is made for the 20 km approach, is 4860.76±0.04 and represents a negative displacement of 0.77 A, approximately the same as the former but less extensive measures.

Dominion Astrophysical Observatory,
Victoria, B.C.,
December 30th, 1920.

THE AMERICAN ASTRONOMICAL SOCIETY: CHICAGO MEETING

By C. A. Chant

The regular meeting of the above Society is usually held early in September, but on the occasion of the large leap-year meetings of the American Association for the Advancement of Science the Society meets with it, practically assuming the place of Section D.

The sessions were held on Tuesday, Wednesday and Thursday, December 28, 29, 30, 1920; and nearly fifty papers were presented. The attendance was about 75 and discussions on the papers were interesting and active. Amongst those present were four from California, including Mrs. Isaac Roberts; and from Canada there were five, namely Messrs. Stewart, Smith and Hodgson of the Ottawa Observatory, H. H. Plaskett, of Victoria and the present writer.

The papers may be grouped under several heads as follows:—

Sun and Solar System

E. E. Barnard, Observations of the present disappearance of the Rings of Saturn.

F. Slocum, Photographic distortion on eclipse plates and the Einstein effect.

O. J. Lee, Motions of the Prominence of October 8, 1920.

Dinsmore Alter, Sun-spot intensities as components of a Fourier series.

R. E. De Lury and *J. L. O'Connor*, Some measurements of the displacements of spectrum lines in the penumbrae of sun-spots.

E. E. Barnard, Probable explanation of the apparent elongation of the gegenschein.

R. E. De Lury, The search for the gravitational effect predicted by Einstein for solar wave-lengths.

R. E. De Lury, Second note on the displacements of spectrum lines at the limb of the sun.

R. E. De Lury, Further note on fluctuations in the moon's longitude in relation to meteorological variations.

L. Silberstein, Secular motion of perihelion due to the dragging of a compressible ether.

L. A. Bauer, The system of magnetic forces during the solar eclipse of May 29, 1919.

Miss Young, On the probable reason why certain periodic comets have not been found at their predicted returns.

STARS AND NEBULAE

Philip Fox, Stellar parallaxes determined at the Dearborn Observatory.

W. S. Adams and *A. H. Joy*, Note on the comparison of spectral types determined at Harvard and Mount Wilson.

S. Albrecht, Additional evidence on changes of wave-length which are progressive with stellar type.

H. H. Plaskett, The intensity distribution in typical stellar spectra.

R. H. Baker, The association of hydrogen lines with the "invariable" K line in the spectrum of Kappa Draconis.

R. H. Curtiss, An instrumental source of doubling of the emission lines in the spectrum of Gamma Cassiopeiae.

E. B. Frost, On some "irreconcilables" among stellar velocities.

F. R. Moulton, On the age of the stars.

W. S. Adams and *A. H. Joy*, Evidence regarding the 'giant' and 'dwarf' division of stars afforded by recent Mount Wilson parallaxes.

O. J. Lee, Progress in the reduction of the Kapteyn zone at North declination 45°.

Joel Stebbins, On some new variable stars.

F. Henroteau, The photographic light-curve of Nova Cygni No. 3.

J. A. Parkhurst and *E. B. Frost*, Objective prism spectra of Nova Aquilae No. 3 and Nova Cygni No. 3.

S. B. Barrett and *E. B. Frost*, Comments on the Spectra of Nova Cygni No. 3 and Nova Aquilae No. 3.

W. E. Harper, Notes on Nova Cygni No. 3.

C. O. Lampland, Recent photographic observations on several well-known novae.

E. E. Barnard, Visual observations of some of the novae.

V. M. Slipher, Spectrographic observation of rotating spiral nebulae.

F. Henroteau, The North America nebula.

DOUBLE STARS.

J. Paraskevopoulos, Orbit of the binary 65 Tau Cygni (Period 3h 25m).

R. K. Young, The spectroscopic orbit of Omicron Draconis.

J. S. Plaskett, The spectroscopic orbit and dimensions of Z Vulpeculae.

G. Van Biesbroeck, Progress of the measurement of the Hussey double stars.

G. C. Comstock, Some new methods for double star orbits.

E. B. Frost and *S. B. Barrett*, Sundry spectroscopic binaries.

W. E. Harper, The spectroscopic orbit of Boss 5070.

INSTRUMENTS AND MISCELLANEOUS

F. E. Ross, A wide-angle astronomical doublet.

R. M. Stewart and *C. C. Smith*, Circle flexure of the Ottawa meridian circle.

R. M. Stewart, Chronographic measurement of small time intervals.

R. M. Stewart and *J. P. Henderson*, Recording of Wireless Time Signals.

C. C. Wylie, Note on the effect of the barometric gradient on meridian observations.

D. W. Morehouse, The Des Moines Municipal Observatory.
F. E. Ross, The Kotinsky effect.
F. H. Seares, Comparative tests of the 100-inch and the 60-inch reflector.

Abstracts of these papers will be printed in *Popular Astronomy* and then in the *Publications* of the Society.

One of the most interesting papers was the first in the above list. Professor Barnard stated that the naked eye could detect a wire 0".43 wide seen against a fairly bright sky, although a dark spot must be 25" wide to be seen. At one time the rings of Saturn could not be seen in the 40-inch Yerkes refractor, from which he concluded that they must be less than 50 miles and probably less than 25 miles in thickness. Another interesting result announced was that the spectroscopic binary 65 Tau Cygni has the shortest period on record, namely 3h 25m.

On Wednesday evening there was an enjoyable dinner with the mathematicians in the Quadrangle Club, and on Wednesday morning the astronomers attended a joint session with the physicists, on which occasion Professor Michelson described his measurement of the angular diameter of Betelgeuse from which result it was deduced that this star's diameter is equal to that of the orbit of Mars or 280 millions of miles.

THE INTERSTELLAR CLOUDS OF METALLIC GASES

By F. Henroteau

The question as to whether space is absolutely empty or is filled with some kind of matter, has always puzzled the thinking mind. The recent researches concerning the constitution of the universe, or the many universes, either photographically or spectroscopically, are beginning to throw new and important light on the subject. We presume at present that spiral nebulae are so many stellar universes and we find more and more evidence that there is absorption in space, at least local, and that that absorption is greater toward the region of the Milky Way than toward the galactic poles. Two kinds of absorption have to be considered; that which might result by the presence of meteoric dust, or that which is due to the existence of enormous volumes of gas. The presence of the first one has been considered by J. C. Kapteyn in his study of the distribution of the stars, as well as by Tikhoff in Russia and Nordmann in France, utilizing their methods of monochromatic images. Kapteyn considers that the colour index of a star can be expressed in the following way:

$$a + bm + cM + d\Delta$$

in which m is the apparent magnitude, M the absolute magnitude of the star, and Δ its distance or $0''.1/\pi$, and where b, c and d indicate the variations of redness due respectively to a change of one unit of apparent magnitude, one unit of absolute magnitude and one unit of stellar distance or 32.6 light years (decaparsec). Kapteyn concluded from his investigations that on this unit of stellar distance the loss of light for the photographic rays increases the magnitude by $0^m.0055$ while the loss of light for the visual rays increases the magnitude by $0^m.0027$; in other words for stars of the same constitution (spectral type, temperature, etc.) the farther they are, the redder they will appear. If there is absorption of light in space, there must be also dispersion, which means that lights of different wave-lengths would have different speeds of propagation. Tikhoff thought this might explain the slight difference of time which separates the maximum of the light curve of δ Cephei from the

maximum of its velocity curve; he also thought that in spectroscopic binaries of short period the velocity curves given by lines of different wave-lengths would be slightly displaced in time, with respect to each other. Along the same lines Nordmann thought that the light curve obtained with a blue screen would be slightly displaced with respect to light curves obtained with a red or a yellow screen, since the lights that go through these different screens have taken different times to come from the star to us, and he actually found such displacements. These displacements are very small, however, and since it has been shown by Shapley and others that the spectra of Cepheids vary along the spectral sequence with the intensity of brightness, there would be no surprise in finding such small changes of phase for lights of different wave-lengths. The same for Algol variables, there is a change in colour due to the fact that the eclipsed component is of a different spectral type than the eclipsing component of the binary system. The stars investigated by Tikhoff and Nordmann having been mostly Cepheids, the displacements they found is no proof of dispersion in space. The existence of meteoric dust in interstellar space is possible, even probable, but we may consider that it is not proved; such meteoric dust or meteoric particles in space would help us a great deal in the explanation of a great many celestial phenomena such as stellar variations, conservation of stellar energy for exceedingly long periods of time, etc. .... it was indeed the supposition of such an existence of meteoric matter that gave birth to the famous meteoritic hypothesis of Sir Norman Lockyer.

The existence of absorption due to gaseous clouds, at any rate in vast parts of our stellar universe, is no more to be doubted. First the fact that there is no spiral nebula near the galactic equator and that the number of these nebulae increases many times when nearing the galactic pole, seems to point out that the greater thickness towards the galactic equator of an enormous absorbing medium, prevents our seeing them in the direction of this equator. Also by similarity, if spiral nebulae are outside universes, since most of them seem to be filled by absorbing material, especially when seen edgewise (when usually a dark band divides them in two parts) it seems that our own universe must also contain such a great quantity of absorbing material. Barnard's photographs

of the Milky Way may be said to be one of the first best proofs that great tracts of nebulosity, bright and dark, are spread in our stellar universe. On these photographs, as well as those of Isaac Roberts and of others, one can see many nebulosities of a great variety of sizes and shapes; their spectra indicate generally a gaseous state although the spectral types of the fainter ones are for the most part unknown. Two of these nebulae, however, that which surrounds the Pleiades cluster and the other which is around the bright star ρ Ophiuchi, according to V. M. Slipher, have spectra identical with the brilliant stars which seem to be immersed in them; that is, continuous spectra, with absorption lines of helium and hydrogen. The photographs taken not only with short focus lenses such as the Willard lens, used by Barnard, but also by the largest photographic telescopes, are confirming William Herschel's observation that the large and chaotic nebulae are in or are bordered by regions of the sky having fewer stars than abound in the surrounding regions; such a great deficiency of faint stars occurs, namely, in a large part of the constellation of Orion especially in the adjacent areas of the great nebula; W. H. Pickering found also that a very large part of this constellation contains a great many faint nebulosities; the same is true of the region of the Pleiades and of many other regions in the Milky Way, where nebulosities and enormous patches or dark alleys, devoid of faint stars, find their way amidst clouds of innumerable stars; the nebulosities and dark alleys in the neighbourhood of ρ Ophiuchi constitute one of the most striking examples. Astronomers of to-day do not doubt any more that these dark regions are due chiefly to the fact that clouds of nebular material are in front of more distant stars or envelope these stars.

To give a more concrete example, let us examine the accompanying photograph which has been taken by the writer at the Dominion Observatory with a short focus lens, and which was skilfully enlarged by Mr. Steadworthy. The region is that of the North America nebula, not far from α Cygni in the Milky Way; the North America nebula is not as sharply defined as on some other photographs, namely those of Barnard[1]; on the other hand

[1] *Lick Observ. Publ.*, *11*, plate 78.

although containing fewer stars (the lens being an F6 and an exposure of three hours only having been taken) it shows a much greater tract of nebulosity. Measured with a planimeter, on this photograph, the area covered by the nebulosity is 10.5 square degrees, while the area covered by the North America nebula alone

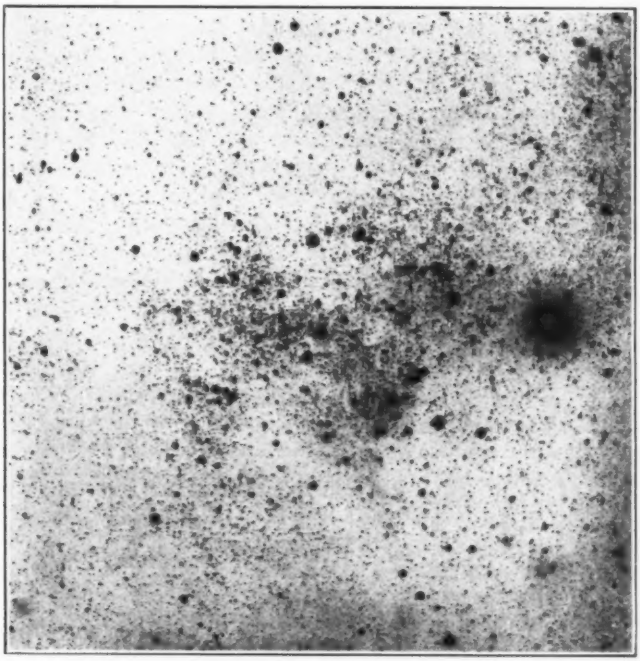

Figure 1—Region of North America Nebula, near Alpha Cygni

is only 1.6 square degrees. Let us now try to find out approximately what an area in space this nebula would cover; an estimate of the parallax of the North America nebula has been made by Buch Andersen in Copenhagen. Buch Andersen bases his estimate on the following hypotheses: the bright stars in the region of the nebula are nearer than the fainter ones; for nearer stars on the whole, there would not be any obscuration in the regions of the dark rifts, *i.e.*,

their distribution must be uniform, while for further away stars, decrease of stellar density in the regions of the rifts ought to be noticed; Buch Andersen, basing his researches on the work of Kopff[2], who determined the variation of stellar density in the region of the North America nebula, found that for stars brighter than the 8.4 magnitude, the distribution may be considered as uniform, while for stars fainter than the 8.4 magnitude the distribution follows that of Kopff. As the mean parallax of stars of the 8.4 magnitude is, according to Kapteyn, 0″.007 we might consider that the parallax of the North America nebula is of that order. Buch Andersen proposes to utilize this method of determination of parallax to other extensive nebulosities of the Milky Way. There is possibly one objection to his method, it is that, in most nebulous regions the brightest stars themselves seem to be enmeshed in the nebulous clouds and are not in front of the nebula. The photographs of the Pleiades, for instance, show plainly nebulous arms going from one star to the other; then there are the nebulæ observed by Slipher in which the nebulosity shows a spectrum identical to that of the bright stars, the nebulosity possibly reflecting the light of these stars. Besides, a great number of the bright stars that are in nebulous regions are of class B, have wide and diffuse lines, very indicative of being plunged in the nebulosity. Taking a few measured parallaxes of B stars, we have the following table:

	Star	Sp.	m.	Rel. π	Authority
c	Persei	B3	4.0	$+0''.008 \pm 0''.009$	Schlesinger
π^4	Orionis	B3	3.8	$-0''.012 \pm 0''.007$	"
ψ	Orionis	B2	4.7	$-0''.019 \pm 0''.015$	"
P.G.C.	5210	B7	5.8	$+0''.006 \pm 0''.002$	van Maanen
P.G.C.	390	B9	5.8	$+0''.015 \pm 0''.077$	"
ϵ	Cassiopeiae	B5	3.4	$-0''.006 \pm 0''.003$	Lee and van Biesbroeck
β	Lyrae	B2p	3.4-4.1	$-0''.011 \pm 0''.010$	"
66	Cygni	B3p	4.4	$+0''.013 \pm 0''.003$	"
β	Canis Maj.	B	2.0	$+0''.007 \pm 0''.010$	McCormick Observatory
ν	Scorpii	B3	4.3	$+0''.010 \pm 0''.010$	"
P.G.C.	6142	Bp	6.0	$+0''.025 \pm 0''.010$	"
38	Persei	B	3.9	$0''.000 \pm 0''.007$	Daniel and Schlesinger
19	Lyncis	B8	5.6	$+0''.007 \pm 0''.008$	"
4	Geminorum	B9	6.7	$0''.000 \pm 0''.007$	Hudson

[2]*Publ. Astroph. Inst.*, Heidelberg, *1*, 181, 1902.

68	Herculis	B3	Var.	$-0''.023 \pm 0''.010$	Schlesinger and Miss Denton
λ	Tauri	B3	Var.	$-0''.012 \pm 0''.008$	Schlesinger and Miss Stocker
σ	Cygni	B8p	4.3	$-0''.007 \pm 0''.009$	Schlesinger and Miss Knudsen
β	Tauris	B8	1.8	$+0''.005 \pm 0''.001$	van Biesbroeck and Mrs. Pettit
P.G.C. 5083		B2	5.5	$+0''.007 \pm 0''.005$	van Maanen

66 Cygni, σ Cygni and P.G.C. 5083 are three stars in the neighbourhood of the North America nebula.

If we consider the North America nebula as being at about the same distance as these stars, we see that the estimation of Buch Andersen, of $+0''.007$, might be taken as the approximate parallax of that nebula. In other words, the distance away from us of the nebula is of the order of 143 parsecs or 466 light years; the greatest length of the nebulosity on our photograph is about 4°, which means that this greatest length in space would be 10 parsecs, and as the area of the nebulosity is 10.5 square degrees, it means that this area in space would be 65.6 square parsecs. Its greatest length visible on the photograph being 10 parsecs or 32.6 light years, is only a lower limit of what the thickness of the nebulosity might be. Remembering that the distance of the nearest star α Centauri is only 1.3 parsecs or 543,000 times the mean solar distance, one can see that the greatest length of the nebulosity is of the order of 5,000,000 times the mean solar distance, which is 149,501,000 kilometers; this is however a low value, as absorbing material extends on much larger areas, as can be seen from the areas of small stellar density that divide up the star clouds (Barnard photograph, *Lick Obs. Publ.*, *11*, Plate 78). An interesting fact to notice, also, is that *where the nebulosity is bright a greater number of stars can be seen, faint as well as bright.*

The problem of the existence of interstellar volumes of gas can also be regarded in the light of spectroscopic data of another form, especially since, in 1904, Hartmann announced that in the spectrum of the class B star δ Orionis the sharp K absorption line of calcium did not share the periodic variations of position of the other broad absorption lines.[1] Hartmann suspected that a similar

[1] *Ap.J.*, *19*, p. 268.

result would be obtained for the H line; the observation of this latter is however more difficult as being so near the line H_ϵ of hydrogen. He concluded, what seems very logical, that these H and K lines do not belong to the spectrum of the star itself but are due to the absorption of enormous clouds of calcium situated between the star and us. He called these lines, *stationary lines of calcium.*

After Hartmann, a certain number of observers have discovered similar phenomena in other stars; V. M. Slipher, namely, gathered a great deal of information; he not only showed that stationary calcium lines existed in a great many early class B stars, but that these stars were situated in the same regions of the sky, usually in the Milky Way, and where photographs taken with a wide angle camera such as those of Barnard, Max Wolf or Isaac Roberts, show, not only nebulosities, but also enormous darkened spaces. For instance, after having found that the spectrum of β Scorpii contained sharp stationary calcium lines, he found that the same happened for σ Scorpii, δ Scorpii, ν Scorpii, ζ Ophiuchi and a certain number of fainter stars between Antares and β Scorpii. All these stars' spectra have wide and diffuse lines in general, with a sharp K line; τ, π, and μ Scorpii seem also to have faint absorption lines of calcium although in their cases the fact that they are stationary is rather doubtful. A certain number of class B stars in Orion and in Perseus were found by Slipher to exhibit the same phenomenon in their spectra. An investigation by myself of 42 spectra of early class B stars which were taken at the Dominion Observatory by Mr. Henderson and myself led me to find the following characters for their K line of calcium—

η Aurigae	faint K	
η Ursae Maj.	faint sharp K	lines wide
μ Eridani	"	"
σ Orionis	"	lines diffuse
κ Orionis	"	"

π^5 Orionis: on plate 8865 which gives a rather high velocity of +63.1 km (not corrected for the sun), there are two K lines, a fairly diffuse one, having the same character of diffuseness as the other lines of the star, displaced toward the red, and a faint sharp one almost not displaced.

λ Cassiopeiae	faint sharp K	lines wide
κ Cassiopeiae	sharp K	other lines sharp
ζ Cassiopeiae	*apparently no* K	but other lines sharp
γ Cassiopeiae	perhaps faint sharp K	lines wide + emission
ξ Arietis	faint sharp K	lines wide
δ Ceti	faint sharp K	but other lines sharp
H.R. 985	faint sharp K	lines exceedingly wide + wide emission
20 Tauri	narrow rather diffuse K	lines narrow rather diffuse
ζ Persei	sharp K	other lines sharp
ϵ Persei	diffuse K	other lines diffuse
ν Eridani	sharp K	other lines sharp
θ^2 Orionis	faint sharp K	other lines wide + emission
ζ Orionis	sharp K	other lines narrow
χ^2 Orionis	sharp K	other lines sharp
η Hydrae	faint sharp K	other lines rather wide
κ Draconis	faint sharp K	other lines wide and diffuse
θ Coronae Borealis	*no* K *line, or exceedingly faint*	other lines wide and diffuse.
δ Scorpii	perhaps faint sharp K	other lines diffuse
22 Herculis	sharp K line	other lines sharp
15 Draconis	wide diffuse K	other lines wide and diffuse
c Herculis	sharp K line	other lines sharp
67 Ophiuchi	"	"
102 Herculis	"	"
4 Aquilae	faint sharp K	other lines wide
η Lyrae	sharp K	other lines sharp
1 Vulpeculae	apparently no K line	
8 Cygni	sharp K line	other lines sharp
ι Aquilae	faint sharp K	other lines a little diffuse
12 Vulpeculae	diffuse K	other lines diffuse
17 Vulpeculae	faint sharp K	other lines diffuse
28 Cygni	"	"
H.R. 7739	faint wide diffuse K	other lines wide and diffuse
ϵ Delphini	sharp K	other lines rather sharp
55 Cygni	sharp K	other lines sharp
66 Cygni	faint sharp K	other lines wide diffuse + emission
β Cephei	"	other lines rather sharp

An examination of the above table shows us, first, that in the star π^5 Orionis there are two K lines, one being undoubtedly of stellar origin; we could hence hardly say that the origin of the other is stellar. No doubt, for some position of π^5 Orionis in its orbit, the two must blend. A great number of stars with wide and diffuse lines show unmistakably a faint sharp K line.

θ Coronae Borealis is a remarkable exception; its spectrum has very wide and diffuse lines, but it is situated at a certain distance from the Milky Way. We see that most of the early class B stars with wide lines are situated in the Milky Way and so are also fainter class B stars; in order however to admit the hypothesis that a cloud of calcium gas is in front of the stars of some region of the sky, it would be well to prove that a stationary K line exists in all the spectra of stars of this region. This can only be proved for early class B stars, since, in other spectral classes there is always a very wide and strong K line which would evidently absorb any faint interstellar calcium, unless the star to which it belongs should have a very high velocity; in this case also, for classes A, F, G or K, an interstellar K line is likely to be lost among the great many metallic lines which fill this region of the spectrum. The only way to tackle the problem is to investigate fainter early class B stars (the fainter ones in the Milky Way being apparently only of the seventh magnitude) and this can only be done with powerful telescopes. Perhaps also, an objective prism of large dispersion and high power could be used to advantage; I examined here a plate taken by Mr. Motherwell with the objective prism of the Dominion Observatory; the dispersion was too small to show the faint stationary K lines to advantage in the many spectra it records, namely 28 Cygni, of the above table, shows a doubtful trace of it. A fact of great significance on that plate, however, is the fairly large number of star spectra with bright lines.

A certain number of astronomers, doubting that the stationary K line in class B stars could be produced by an interstellar cloud, have tried to explain its existence by inventing other hypotheses. For instance, by the presence of a third body, or by extensive atmospheres, or also by invoking the phenomenon of anomalous dispersion in a star's atmosphere, as has been done by Julius. All these explanations, however, do not seem to be entirely satisfactory.

(*To be concluded*)

THE FESTIVAL OF THE DEAD

By R. G. Haliburton

(*Concluded from page 34*)

ADDITIONAL FACTS IN CONFIRMATION OF VIEWS IN THE PRECEDING PAPER.

I have stated that I was convinced that further investigation would supply additional proofs of the correctness of my conclusions as to the history of the deluge. In confirmation of this, I may mention a very remarkable fact that had entirely escaped my notice, and which has been to me not a little startling. Greswell has attempted to show that the 72 priests of the Bull Apis represented the "three families of the sons of Noah, the individuals in which, all together, are always so represented by the commentators of antiquity as to make up the number of 72 exactly." [1] He has also conjectured that the Elders, who mourned for Tammuz in reality must have been at least 71, and probably 72, and must have had the same significance, as the priests of Apis (*i.e.* of Taurus or of Osiris). Now there can be but little doubt that the loss of Tammuz, of Attis, and of Adonis, who was "*enclosed in an ark for a year and a day*," had reference to the occultation of the Pleiades and to time, a fact to which Bion alludes.

"Cease Venus now thy wail; reserve thy fear
Again to fall with each Adonian year." [2]

But there can be still less doubt that Osiris, whose ark was represented by the constellation Argo, was the Egyptian Noah, as this point is conceded by all writers on the subject. But in India, Manu, who was preserved in the ark *Argha*, Sir Wm. Jones shows, is the Hindoo Noah, and each period of Manu or each manwantara consists of 71 years, or as it has been more correctly estimated by Hindoo astronomers 72 years. This is simply a period of Taurus, or the time within which the year of the Pleiades gains one day on the tropical year—a calculation, in which the Egyptians, Hindoos and Scandinavians seemed to have nearly agreed, and to have made a most singular approximation to the true period. If this is the case the 71 or 72 years of the manwantara, the 72 priests of the Egyptian Apis, and the 71 worshippers of Tammuz, must have related to the same astronomical fact. But the Egyptian and the Hindoo periods were connected with the god of the ark; hence it is almost impossible to

[1] Fast. Cath., ii. 555.

[2] Elton's Classic Poets, i. 365. This translation, though not literally correct, gives the true meaning of the original. See Theocritus, Idyl., xiv. 97, 102, 136.

avoid the inference that the 72 sons of Noah had reference to the same period of the year of the Pleiades. But the question arises, if our account is astronomical, how does it conform to the ideas of the ancients as to the time when the deluge took place? Aristotle says, "the winter of every great cyclical year *is a deluge*," which simply means that at the end of every cycle a deluge metophorically takes place. In India the deluge of Menu occurred at the end of a cycle, and the Mexicans attached the same idea to their cycle. Greswell tells us that all over the globe we can find traces of the great lunar cycle of 600 years, called in Egypt the Apis cycle, *i. e.* the cycle of the Bull. This cycle, Greswell says, "so venerable for its antiquity," is *"coeval with the origin of human society."* [3] Apply these facts to our history of the deluge and what do we find? "And *Noah was six hundred years old* when the flood of waters was on the earth."

Sir William Jones says that the mythological ages, which in the Hindoo cosmogony preceded the deluge, were connected with periods of Menu. If so, let us see whether our account does not exhibit the same astronomical character, and whether the era between the creation and the deluge, does not resolve itself into periods of 72 years. Divide 1656 years by 72, and we have exactly 23 periods of the year of the Pleiades.

It is almost impossible that these coincidences can be accidental; they are at least of such a nature as to justify one in bringing them to the notice of the learned, without being subject to the unfair imputation of a desire to throw doubt on the literal character of a history, for which no one can feel a more profound veneration than myself.

These facts have come to my knowledge since the foregoing paper was written, and are deserving of further enquiry. Were this paper published for general circulation, I should hesitate to refer to these facts, not from any doubt as to their correctness, but from fear that they may have a very different effect on the minds of general readers, from what they would produce on the judgments of scholars. If the conclusions that I have been forced to arrive at, are accepted as correct, I am convinced that they can be made entirely consistent with the inspired character of the word of God. It is certainly highly desirable that they should be enquired into by the learned; and as only a few copies of the paper have been struck off, mainly for circulation among scientific societies, I feel the less hesitation in bringing them to the notice of scholars. To suppress all allusion to these facts would be unfair to truth itself; and I am persuaded, as they are the result of

[3] See Fasti Cath., i. 99, 100, 101; also passages cited in Index.

honest investigation and carried on with a perfect conviction of the inspired character of the scriptures, they will be fairly judged and candidly enquired into.

The note to p. 23 will show how I was first forced to examine into this question. The inference to which the facts there alluded to, seemed to lead, have been fully confirmed, and a careful analysis of our history of the deluge will prove that it bears the marks of having been previously transferred from a lunar-sidereal year; that it was inherited by the Jews from a period long anterior to the times of Moses; and that it could not have been derived from the Egyptians.

In consequence of the number of authorities which it was necessary to consult, I omitted to examine Bryant's voluminous work respecting the traditions as to the deluge. I find that almost every page of Vol. II. of his Analysis of Ancient Mythology, bears out my conclusions most fully. This is the more important, as he does not seem to have had the slightest suspicion of there being an astronomical basis for the traditions of ancient nations as to that event. He accordingly proves that all accounts are almost identical with our own; and that so important a part did the deluge play in ancient mythology, that the ark (Argo, Theba, etc.) and the dove, not only gave names to numerous cities, but also to divinities. But he shows that the influence of a myth as to a Bull (*which he does not explain*), was equally conspicuous, and that the *tors* of Greece and Asia were more numerous than those of Great Britain. Even where he gives a plate of the Bull Apis with a dove on its back, he does not seem to suspect that it referred to the Pleiades on the back of Taurus. He has shown that the Argonautic expedition was simply an allegory as to the deluge.

I would invite the attention of scholars to the Hesiod's Theogonia, and to the Argonautica of Orpheus, as well as to the passage cited from Pindar in Sir William Jones' works, IV. 57. If we simply bear in mind that Argha was the Ark of Manu, and that Argo, or Argos, and Theba (called Bous by the Syrians) or Thebes and its *seven* gates, referred to the ark; that Pelias, the Peleiades, Pelion, Peleus and Phasis so constantly mentioned, are all indirect allusions to the Pleiades (the doves of the deluge or of time); and that the references to Taurus and Thera point not to a country or place, but to a constellation, the astronomical character of these allegories will be apparent. That the memory of the Flood had become blended with the idea of time and of the year is clear from the fact that the oldest heathen author in his account of the creation, and of the early history of the world, does not allude to the deluge. When it is remembered that

Orpheus and Cadmus, to whom Grecian mythology points as having introduced religion and learning into Greece, came from Phoenicia, the silence as to the deluge observed by the Phoenician author Sanchoniatho, who must have written long before the fables of Orpheus were known in Greece, is the more important and the more significant. This circumstance has already excited some surprise. Cory says, in his Ancient Fragments, p. ix.: "It is remarkable that Sanchoniatho is almost *the only heathen writer upon antiquities who makes no direct allusion to the deluge,* though several obscure allusions to it may be found in the course of the fragment. Were we assured of his silence upon the point in the parts of the work which have been lost, the omission *might still be accounted for from his avowed determination to suppress what he considered merely allegorical,* for he would find the traditions of the deluge so intimately blended with those relating to the creation, that on endeavoring to disentangle the truth from the fable, he might easily be induced to suppose that they related to the same event."

But so intimately had Taurus and the Ark become blended with Time itself, that the very passage in Sanchoniatho describing the fact, indirectly attests to the truth of his assertions:

"Chronos (time) visiting the country of the South, gave all Egypt to the God *Taaut*us, that it might be his kingdom." The latter was, he tells us, called *Thoor* in Egypt. "These things,' says he, "the Caberi, the *seven sons* of Sydye, and their brother Asclepius, first of all set down in the records in obedience to the commands of the God Taautus," which simply mean that *Time* gave the account to Thor or Taurus, and that the Pleiades wrote it on the records. But this singular allegory continues in the same strain: "All these things the son of *Thabion*" (*Theba* an ark) "the first Hierophant of all among the Phoenicians, *allegorized and mixed up with the occurrences of nature* and the world, and delivered to the priests and prophets, the superintendents of the mysteries; and they, *perceiving the rage for these allegories increase,* delivered them to their successors, and to *foreigners.*" [4]

I think that no one who reads the learned works of Bryant and Faber, and the early mythological poems of Greece, with the new light which the Aztec commemoration of the deluge sheds on the subject, can fail to see that Orpheus and other early Greek writers composed works which, under the semblance of history, were simply poetical versions of astronomical truths, intelligible perhaps to the initiated, but unintelligible to the generality of mankind, and that these allegories contain continual allusions to Taurus, the Pleiades and to Theba, veiled under words having

[4] Cory's Ancient Fragments, p. 16. Euseb. Praep. Evan., i. c. 10.

an analogous meaning or an identity in sound to the names of that constellation or of the ark. The continual repetition of the same names is enough in itself to suggest that there must have been some hidden truth veiled under these fables; and that they must have been written in what was called *"the language of the Gods."*

The ship Argo, Plutarch says, was made a constellation, as being the ark of Osiris. All the incidents of the Expedition of the Argonauts, which Newton regards as an historical narrative, clearly refer to primitive festivals and superstitions. The golden fleece hanging on the sacred tree, can be obtained to this day with but little danger by any one who is willing to outrage the superstitious veneration of the Russian peasantry for sacred trees which they still adorn with wool and yarn, a custom, traces of which are to be found in Asia, Africa, Australia and America—(see Took's View of the Russian Empire, II. 372). The Cauldron of Medea was well known to the early inhabitants of Britain as the cauldron of the year and of the Flood, which was "regarded as *an emblem of the deluge itself,"* and was *"kept boiling for a year and a day"* (Davies' Myth. of British Druids, p. 226); and as to Jason bathing *at midnight* as a protection from the spirits, and throwing a stone among the ghosts whom he had conjured up, as a means of "laying them," a fable told also of Cadmus, we have the explanation in the history of the flood of Deucalion, in the funeral rites of the Hindoos, in the superstitions of the New Zealanders, and in the ceremonies at the Lemuria, the Roman "festival of ghosts."—(See ante, p. 48, 72, note, 111. Ovid Fast. v. 437. Or. Kal. Ital. I. 301, 305. Sirr's Ceylon, II. 199. The Mahavansi, III. 150. Le Peuple Primitif, II. 179.)

The fables of Orpheus and Eurydice, of Ceres and Proserpine, are merely poetical versions of popular superstitions that still exist among some of our peasantry, as to fairies. Eating the food of the "good people," is still as dangerous as eating pomegranates in Hades once was; looking *back at Halloween,* is as unlawful as it was at the "festival of ghosts," or in the realms of Pluto; and the cake offered to Cerberus still exists in our *somas* or "All Soul's" cake, and in the *mukbipoyo* of the Yucatan Indians.

But the hand of time has been more merciful than the imagination of the poet, and has preserved more distinct relics of primitive society in the customs of the people, than are to be found in the allegories of Grecian mythology. Yet while not only scholars but even school-boys are expected to be familiar with all the fables of antiquity, the learned have too often despised as unworthy of notice the living memorials of primeval man that are still preserved in the superstitions and festivals of nations.

The references which I give to the works of Bryant, Sir William Jones, Faber and Greswell, will be found to bear on the subject of this paper; and as they have regarded the history of ancient mythology in an entirely different light from that suggested by myself, their views will be entitled to more weight than any facts that I could advance in support of my conclusions. It must be remembered that the identity of our history of the Deluge with that of heathen nations, has been established already by authors who are in no way liable to the charge of scepticism. Bryant and Sir William Jones can hardly be accused of this, and least of all Greswell, whose works are devoted to proving that miracles in the times of Joshua and Hezekiah caused those remarkable features in the calendars of nations, which I have endeavored to account for by the year of the Pleiades. If the points of identity in the traditions as to the deluge are in one instance found to be connected with astronomical phenomena, all of the histories of that event must also share in the same peculiarity. It is clear that Bryant's solution (II. 432) for the singular connection of Taurus or a Bull with ancient mythology and with *Theba*, the ark or the deluge, is unsatisfactory, and that an unsolved riddle of the *Sphinx of Thebes, the mystery of the Ark*, can only be unravelled by the clue which the Aztec festival has supplied to us.

I would particularly invite attention to the following passage from Sir William Jones' works (IV. 12), which shows that that most eminent author, whose orthodoxy but few will question, not only was struck by the resemblance between our history of the Deluge, and that of the Hindoos, but also must have had some doubts whether all accounts of that event are not of an astronomical and figurative nature. Let us compare the two Indian accounts of the creation and of the Deluge with those delivered by Moses. *It is not made a question in this, whether the first chapters of Genesis are to be taken in a literal or merely in an allegorical sense;* the only points before us are, whether the creation described by the first Menu, which the Brahmins call that of the Lotos, be not the same with that recorded in our Scripture; and whether the story of the seventh Menu be not one and the same with that of Noah. *I propose the questions, but affirm nothing.*"

There will be found in Bryant's Analysis, I. 501, a most interesting confirmation of the conjecture as to the Graces representing the "pleasant influence" of the Pleiades, as, according to him, their name was originally *Tor* Charites—not *Tri Charites*. There will also be found in I. 297, II. 159, 162, 276, 424, a variety of proofs as to the symbol of the Tau having left a very marked impress on the alphabet. Alpha in the Phoenician language meant

both a letter and bull, and Thor was the Phoenician word for a bull. The crux ansata or the Tau surmounted by a ring among the Egyptians represented A, as the simple Tau on the scarab did T. Hence we must infer that as they must have been sacred symbols before they became letters, the T or the scarab represented the three Taus or seasons of the Pleiades, and when surmounted by a ring the year (and hence the god) of the Pleiades or Taurus, which must have been Ataur. We can therefore understand how the Tau represented T, and Ataur A. To show that this is the case, we find that among some nations the triangle represented the letter D or T. But the Bull Apis is represented with a triangle on his forehead, and hence it would seem that the symbol must have been like the T called Tau, and that it must like that emblem have represented the three seasons of Taurus. I am aware it afterwards got another significance, both in India and in Egypt, but that it had an astronomical origin few can doubt. This emblem, like the Tau, the cross and the serpent, is to be found in almost every part of the globe, and even among the races of the New World. In a system of writing which is peculiar to the Micmac tribe inhabiting Nova Scotia, I have found that the emblem for the Deity was a triangle; and the Rev. Mr. Kauder, a learned German priest who has devoted particular attention to the characters used by the Micmacs, has come to the same conclusion to which I had been led, that that symbol must have been in use among the Micmacs, and was not suggested by the early missionaries, who added to the system some signs which can easily be distinguished from those previously in use. Among the articles found in the Indian mounds of the United States, is one inscribed with characters or symbols, of one of which, shaped like a triangle, the learned author of Prehistoric Man (II. 186, 190), says, "it is the Greek Delta, which is also the letter T or D in several of the ancient alphabets. This character is also the letter *Tyr* in the Icelandic Runic, representing the *God Tyr* or a *Bull.*" Professor Wilson arrives at the conclusion that the emblem had an astronomical significance. I would draw attention to the very striking confirmation which this affords of my conjecture in note to p. 98, that the name of the god *Thor* of the Scandinavians, was the same as the Phoenician word Thor a Bull, and must have originally signified the constellation Taurus, or the God of the Pleiades. It is worthy of notice that while in ancient alphabets we find the letter Tau represented by the cross, the Tau cross, and by a triangle, we find traces of all these symbols still lingering in Britain, as illustrated by the *"Dor"* (Tau) beetle, the hot *cross bun,* the triangular form not only of the *somas* (soul-mass) cakes used on "All Souls," but also of the New Year's cake of

Thor, or Taurus. A writer in the Illustrated London News in 1857, asked the question what could have given rise to a custom which he had observed near Coventry, of using triangular shaped cakes at the beginning of the year. But a reference to Brand's Popular Antiquities (ed. 1853), I. 312, 372, 389, 391, 394, 546, will show that this custom and traces of the ideas originally connected with it, are to be found in many parts of Great Britain, and even in France. The widespread reverence for these symbols that must have once existed, will appear from the following authorities, which are only a few out of very many which I have collected on this point: Catlin's American Indians, II. plate 287; Mallet's Northern Antiquities, 118, 227; Maurice's Indian Antiquities, I. xxviii; II. 172; III. 442; IV. 445, 558, 566; VII. 623; Stevens' Yucatan, II. 259, 313, 315; Kerr's Voyages and Travels, XXV. note to p. 77. Archdeacon Williams' Essays, p. 41. It is not therefore improbable that the triangle and seven stars of Masonry may have an antiquity fully equal to that which tradition among the fraternity has assigned them.

But what a light do these trivial customs and symbols throw on the words of the most ancient heathen author on the subject:— "From Misor descended *Taautus*, who invented the writing of the first letters; him the Egyptians called *Thoor* (Thor), the Alexandrines Thoyth, and the Greeks Hermes. But from Sydye descended the Dioscuri or Caberi, or Corybantes, or Samothraces; these, he says, built the first ship," *i. e.* the ark. But the two Dioscuri were alternately for six months visible and invisible, and the Cabiri *were seven* in number; and as to their building the first ship or the ark, the meaning is apparent in the connection of the year of the Pleiades with the deluge. Thoor (or *Thor* as Taurus was called by the Phoenicians) invented the first letters. What they were is afterwards described. "All these things the son of *Thabion*" delivered to his descendants and to foreigners, "of whom one was *Isiris*, the inventor of *the three letters*." This is simply a play upon words. As *Theba* meant an ark and a bull, the son of *Thabion* simply means Thor, or the god *Taurus*, and Isiris or Osiris was represented by the Bull Apis, and was plainly the god *Thor*. Hence *Taurus* invented the three letters—*i. e.* three of the symbols of the year of Taurus became letters in the alphabet. These symbols, I am convinced, were the *tau*, the cross, and the triangle, and two of the letters were clearly Alpha and Tau.

Although my conjecture that traditions as to the *Spring* point to a migration from the South, may be considered as questionable, I would invite attention to the progression of the year of the Pleiades in connection with the seasons of the South. I am aware

that it will be regarded as an act of very great presumption for a Colonist to endeavor to give a clue to what has hitherto never been explained by the learned; but it must be remembered that by using new historical materials, viz., universal festivals and universal symbols, I may have found a simple clue which profound learning and enquiry have hitherto sought for in vain.

That these investigations have not in every instance led to mere fanciful conclusions will be proved by a confirmation from a work which I obtained from England after the addenda were nearly finished. The passage did not attract my attention until after the paper on the festival of the dead and the addenda were printed.

I have stated that that commemoration is "derived by all nations from primitive man," and that additional proofs could be supplied when I had more space at my disposal. The American Indians erect on graves what they call "a *prayer pole*." This phallus (φαλλος, a pole) is the rude prototype of many well known emblems of heathenism. In Peru it became a stone pillar; in India the column on the grave was called a lingam, and in Rome the post or the pillar on the grave was decorated, like the Hindoo and Peruvian column, and like the primitive "prayer pole," with cloth or lights. The prayer pole, however, like the triangle, almost lost its meaning and its history among the ancients; and the worship of the Phallus (or the *pole*), like that of the Lingam, became associated with the most degrading ideas of the religions of antiquity.

With these remarks, I shall leave the following passage from Sanchoniatho, with this paper and all its numerous misprints, and probably mistakes, to the consideration of the learned. Speaking of the first of the human race, he says—"When these men were dead, those that remained *consecrated poles to them, and worshipped the pillars, and held anniversary feasts in their memory*" (Τουτοις).

Though Bryant's work, as well as that of Faber, is devoted throughout to the subject of this paper, the following references may be of service:—I. 94, 149, 162, 236, 297, 317, 333, 364—403-4, 440, 476—485, 501; II. 1—13, 100, 105, 121, 124, 150—152, 159, 193—250, 254, 276, 280, 282—335, 368, 401, 420—436, 460, 473; III. 427, 441, 486, 588. Faber's Origin of Pagan Idolatry: B. I. ch. iv. v. B. II. ch. vi. B. IV. ch. i. iii. Ch. iv. throws much light on the myths as to Attis and Adonis. B. V. ch. ii. iii. vi. vii. Ch. viii. contains many facts as to King Arthur, confirming my conjectures. De Rougemont, Le Peuple Primitif, II. 175 to 288.

THE END

NOTES FROM THE METEOROLOGICAL SERVICE

DECEMBER, 1920

TEMPERATURE

The temperature was average or below in British Columbia except in the southern portion of the Interior where it was just above the average. It was below in Alberta and in the extreme southwestern portion of Saskatchewan; elsewhere in the Dominion it was above the average, varying from 1 to 4 degrees in Saskatchewan and Manitoba, from 3 to 8 degrees in Ontario, from 2 to 5 degrees in Quebec, and from 1 to 3 degrees in the Maritime Provinces.

TEMPERATURES FOR MONTH OF DECEMBER, 1920

STATIONS	DECEMBER Highest	Lowest
Yukon		
Dawson	6	−30
British Columbia		
Atlin	32	−12
Agassiz	51	18
Barkerville	36	− 5
Kamloops	48	16
New Westminster	51	32
Prince Rupert	51	15
Vancouver	49	32
Victoria	51	32
West Provinces		
Battleford	38	−16
Calgary	50	−17
Edmonton	44	−25
Medicine Hat	59	−36
Minnedosa	34	−30
Moosejaw	49	−20
Oakbank	31	−24
Prince Albert	36	−20
Qu'Appelle	38	−23
Regina	38	−24
Saskatoon	38	−21
Souris	36	−26
Swift Current	50	−22
Winnipeg	32	−22
Ontario		
Aurora	44	5
Bancroft	45	−17
Barrie	..	..
Beatrice	46	−15
Bloomfield	46	4
Chatham	57	5
Clinton	53	1
Collingwood	50	5
Cottam	60	8
Georgetown	49	3
Gravenhurst	45	− 6
Grimsby	54	5
Guelph	51	3
Haliburton	46	−14
Huntsville	46	−15

STATIONS	DECEMBER Highest	Lowest
Ontario—cont.		
Kenora	34	−21
Kingston	49	9
Kitchener	51	3
London	52	2
Lucknow	53	− 3
North Gower	45	−10
Oshawa	41	8
Ottawa	42	− 9
Paris	52	2
Parry Sound	49	− 8
Peterborough	47	3
Port Arthur	41	−13
Port Burwell	52	12
Port Dover	48	9
Port Stanley	48	6
Queensborough	43	− 6
Ronville	..	..
Southampton	51	5
Stonecliffe	40	−26
Stoney Creek	54	5
Toronto	51	11
Uxbridge	..	..
Wallaceburg	45	6
Welland	56	10
White River	40	−34
Quebec		
Brome	42	23
Father Point	36	−16
Montreal	42	− 8
Quebec	36	−21
Sherbrooke	41	−16
Maritime Provinces		
Charlottetown	40	0
Chatham	40	−16
Fredericton	..	..
Halifax	50	0
Moncton	48	− 9
St. John	50	− 8
Sussex	47	−10
Sydney	52	12
Yarmouth	56	4

PRECIPITATION

The precipitation was excessive in many portions of British Columbia, while in a few localities the amount recorded was below the average. In the Western Provinces less than the normal quantity was registered. In Ontario, except in a few isolated places, it was much above the average. In Quebec likewise it was much above the average. In the Maritime Provinces it was much above in the northern portion and below in parts of eastern Nova Scotia. Noticeable negative departures were:—1.67 inches at Victoria, B.C., and 2.79 inches at Sydney, N.S. Marked positive departures were:—Vancouver, B.C., 2.36 inches; Parry Sound, Ont., 3.24 inches; Beatrice, Ont., 3.86 inches; Montreal, Que., 2.58 inches; Anticosti, Que., 2.22 inches; Chatham, N.B., 3.32 inches.

MAGNETIC DISTURBANCES, NOVEMBER 1920

The magnetic forces were unusually quiet during the month of November. Small disturbances occurred at Meanook in D during the night hours of the 3rd and 5th, the range in Declination being 93′.5 and 117′.1. At Agincourt the forces were only very slightly disturbed during this period, the range in D was only 14′.2 and 35′.2 respectively.

On the 26th a small disturbance was recorded in the evening at Agincourt which was most marked in the Vertical component. The range in the Z was 197γ, in H 135γ and in D 46′.8.

On many nights during the month the aurora was nowhere reported. It was most prominent on the 5th and 6th and again on the 12th and 15th.

A small group of sunspots was central south of the sun's equator on the 5th, but following its passage beyond the sun's limb the visible surface was almost free of spots to the end of the month.

W.E.W.J.

SEISMOLOGICAL NOTES FOR DECEMBER 1920

The largest quake for some years past, was recorded on the 16th with trace amplitude of 45 mm and over. The disturbance lasted for four and a half hours, and the swings of the boom were particularly rapid. The preliminary waves were not recorded but

the secondary were shown at 12h 25m 06s at Victoria and 12h 30m 18s at Toronto. The principal portion of the disturbance at Toronto commenced at 13h 0m 8s, continuing to 14h. Newspaper reports from stations on the continent were all at variance, based on first hasty readings of seismograms. On the Toronto and Victoria seismograms, it is exceedingly difficult to interpret the large wave phases, there being so many reflected S waves. Not having sufficiently accurate data at present, we can only give an approximate epicentre, Lat. 47° N., Long. 114° E. or Lat. 42° N., Long. 141° East.

Other small disturbances were recorded on eight occasions.

The total number of earthquakes recorded during the year was 139 in Toronto and 145 in Victoria. This is about 45% greater than average. J.Y.

ASTRONOMICAL NOTES

USEFUL FIELD FOR SMALL TELESCOPES

A Special Field of Usefulness for Small Telescopes by Paul W. Merrill (*Pub. Ast. Soc. Pac.*, Dec. 1920).

Merrill has rendered a service to astronomy by emphasizing that much useful work can be done by either an amateur or professional astronomer who has a telescope even of four inches aperture. The particular work he stresses is the photography of the spectra of stars in the red end of the spectrum, which hitherto has been entirely neglected. All the additional equipment necessary is the prism of 10° to 30° angle to cover the object glass and an attachment to receive the plate. Ilford's Panchromatic plates sensitized by ammonia in alcohol serves to record the region well, and valuable work can be done in noting the variation which the red line of hydrogen (λ6563) undergoes in many stars, a list of which is suggested.

W. E. H.

THE PROBABLE DIAMETERS OF THE STARS

(H. N. Russell in *Pub. Ast. Soc. Pac.*, December 1920.)

From elementary considerations the angular diameter of a star can be calculated if we know its visual magnitude and surface brightness. The problem is to obtain the surface brightnesses. To obtain these indirectly Russell regards as fundamental this proposition: *The difference of surface brightness of two stars (when expressed in stellar magnitudes) is proportional to the difference of their colour indices.* To substantiate this he cites the case of the sun, as there we have differences in colour and brightness over the disk, which, while small, have been measured with great accuracy and which in a fair measure support the proposition.

He then seeks, by half a dozen indirect methods and one direct one, to obtain the constant that expresses the ratio of surface brightness to colour index. The direct method is the case of the eclipsing variable U Cephei, in which the fainter K-type star totally eclipses the brighter A-type component. On a system which gives the colour index of a K-type star as exactly one magnitude he obtains as the mean of his results that the surface brightness is four times the colour index.

The colour index of the various types being determined, he is thus enabled to compute the angular diameters and for this he has prepared a brief table. Where the parallax is known the linear diameter readily follows. From the formula the stars most likely to have large angular diameters would be the red ones, and it seems a remarkable coincidence that the one placed at the head of his table of most likely subjects for testing by the interferometer method should be the identical one which Michelson used in his recent wonderful achievement.

W. E. H.

ON THE SENSITIVENESS OF DIFFERENT PARTS OF THE RETINA

In the November issue of the *Journal of the British Astronomical Association*, Mr. R. L. Waterfield describes some experiments he has made in order to determine the sensitiveness of different parts of the retina. He finds:

1. The outer is more sensitive than the inner side of the retina for red or green light. This is also found to hold in the case of the average star.

2. With green light, the lower is more sensitive than the upper part; but with red light, and also in the case of the average star, the contrary is true.

3. With red light the sensitiveness of direct vision is greater than the sensitiveness of averted vision. While the advantage gained by observing white stars with averted vision is considerable, it decreases and finally disappears as they become red.

4. With red light the greatest sensitiveness is found in the upper and outer quadrants of the retina, between 1° and 3° from the centre.

He suggests that variable star observers use the averted vision method, as the two stars being observed simultaneously the observer does not have to rely upon memory; and for the same reason any effect of fatigue will be the same for both.

J. A. P.

GEGENSCHEIN

In the November issue of the *Journal of the British Astronomical Association* Miss A. G. Cook, F.R.A.S., in an article upon a sun pillar states that some observations of the Gegenschein were reported in March of this year as being "not at all difficult" and "easily seen by others." The Zodiacial Light is best seen in our latitudes in the spring, during the month of March, and as the Gegenschein is sometimes associated with the Zodiacial Light it would be well if our observers keep a sharp look out and report observations on these phenomena.

J. A. P.

THE NATURE OF COMETS' TAILS

Comets' Tails, their true Nature by Major R. A. Marriott, D.S.O. (*Journal of the Torquay Natural History Society, 1920*). 32 pages, 6 plates.

The author rejects the notion of a repulsive force and assumes that a comet is normally spheroidal in shape and composed of rare gaseous matter. This is given an axial rotation as it approaches the sun and it assumes a lenticular shape. A mixture of gases when rotated rapidly will separate, and the gases will tend to segregate in concentric circles round the nucleus. This circular disposition brings the comet into a condition similar to that of an engine-turned metal disc or of a phonograph record, and the reflection of sunlight from this gives the various forms of tails observed.

The comets chosen to illustrate the theory are all ancient ones and the pictures of them were drawn from visual observations. Recent photographs, however, reveal a multitude of details and odd shapes which the theory proposed can hardly explain. The statement that the axial rotation is developed by the comet's approach to the sun can also be questioned on dynamical principles. However, the author makes an interesting attempt to solve a great mystery.

C. A. C.

TWO EXTRAORDINARY VELOCITIES

Two Nebulae with Unparalleled Velocities (Lowell Observatory *Observation Circular*, January 17, 1921).

Dr. V. M. Slipher reports that a plate exposed to nebula N.G.C. 584 (R.A., 1h. 27.3 m.; Dec., −7° 16′) for 28 hours on nights from December 31 to January 14 gave a spectrogram (of solar type) showing that the nebula is receding from the sun with a velocity of 1800 km per second. The nebula N.G.C. 936 (R.A., 2h. 23m.; December, 1° 33′) was photographed with an exposure of 34 hours, and revealed a spectrum of solar type which showed that the nebula is receding with a velocity of 1300 km per second. The two bodies were photographed by Mr. C. O. Lampland with the 40-inch reflector. No. 584 has a brilliant nucleus with little detail in surrounding nebulous matter. Elongation in P.A. about 60°. The nucleus is catalogued in the B.D. as a star of magnitude 9.7. No. 936 shows more detail. The nucleus is large and brilliant, with extensions on opposite sides like the ansae of Saturn's rings, 85″ in length in P.A. 80°. The faint surrounding nebulosity is 2.′5 by 3.′5 with longer axis in P.A. 160°. Both nebulae should be classed as spirals. C. A. C.

CHANGES IN THE OBSERVER, NOT IN THE OBJECT

(*Die Veranderlichkeit der Licht und Farbe-Empfindungen* by H. Osthoff, *A.N.* 5071-72.)

The author refers to the work of many observers, including Osthoff, Plassmann, Schmidt, Klein, Wirtz, Hoffmeister, Müller, Pannekoek, Pickering, Wendell, Nijland, Lockyer, Auwers, Hagen, Ludendorff, Struve.

Conclusions.—It is becoming clearer and clearer that the personality and condition of the observer operate in a variable manner upon the estimation of light intensity and colour sensation. One has hitherto looked upon this in observational astronomy too much from the physical point of view, viz.: that the eye remains in the same condition of sensitivity. But the eye is not a photographic camera nor a telescope, with both of which it is often compared; as a matter of fact it is not similar to any physical instrument.

If an actual change is the cause of the apparent changes observed then it would be observed by all eyes, but of course perfect agreement as to the manner and extent of the change of light can never be attained. The conditions laid down by the committee on variable stars also fail. Gould's well-known saying, that all stars are in a small measure variable, to a degree scarcely greater than the errors of the observations, may be considered correct; because the cause is not to be sought in the stars. Above all things one must free one's self of the notion that the errors of the observer are due to the defects of the eye of the particular observer or to its strained condition. Of course they may be taken as errors but they are of general occurrence and therefore assume the form of a law of nature. They belong to the general imperfections of the human organs of sense. Thiele expresses his opinion on O. Struve's measurements on double

stars as follows: "That his eye was or became more erroneous than was desirable for such observations, which circumstance was a contingency, and he utilized it for the benefit of astronomy." (*VJSd. AG*, 15.347).

As a matter of fact, his eye was probably no more defective than that of others. However, one would know more about this if other observers had repeated the investigations in the manner of Struve.

By the elimination of stars of the Alpha Orion type the theory of variable stars becomes simpler and one is led back to a fundamental cause: the orbital motion and tidal effects caused thereby or mutual eclipses.

Then there remain only the new stars as phenomena apart. True, their sudden appearance indicates a catastrophe, but the conspicuous frequency of their appearance forces us to see in them a process of evolution and not a fortuitous phenomenon in their motion.

The numerous observations of reddish stars have not, therefore, been made in vain; and it would be desirable that the observations should be rediscussed in order to find out how far the personal element enters into the result.

Nothing else remains but to apply biology as an aid to astronomy.

O. K.

PHOTOGRAPHIC SHARPNESS AND RESOLVING POWER

(By Frank E. Ross, *Apl. J.*, *52*, p. 201-231, Nov. 1920.)

This valuable piece of work is a combination of a theoretical development of the principles governing sharpness and resolving power in the photographic image with practical confirmations from the laboratory and with applications to astronomy. Like all photographic problems the question is complicated and the results modified by secondary effects so that the conclusions reached are subject to many qualifying conditions and can hence not be very concisely expressed.

The author develops mathematically the conditions governing the growth of density of the image and also the rate of change of density at the edge of the image which gives a measure of the photographic sharpness. He shows that the sharpness varies directly with the contrast or gamma and inversely with the turbidity of the emulsion. The turbidity of the photographic plate is the property causing the spread of the image beyond its geometrical boundary. A theoretical corollary experimentally proved was the dependence of sharpness upon the wave length of the light employed. The sharpness is at a maximum in the violet, diminishing to a minimum in the green at 5,100 and again increasing towards the red. Contrary to the common belief, sharpness does not depend directly upon the size of grain, and only indirectly because fine grain emulsions usually have higher contrast or gamma.

Photographic resolving power depends upon the sharpness just considered and upon the size of grain but other factors such as exposure time and development enter. Some of these conditions may be popularly expressed in the author's own words, "Consider a pair of close lines being photographed with continually

increasing times of exposure starting from threshold. Resolution is not attained until a certain density of the image has been built up. When the exposure is relatively light only a few scattering grains are affected, so that there is little or no contrast between the image and the surrounding field fog. Two close lines under these circumstances will not be distinguishable. Let the exposure be now increased. The vacant spaces between the scattering grains, which lie at random where the image should be, begin to fill in with grains, the lines begin to outline themselves and finally, when a certain point has been reached, are clearly resolved. This is a description of what happens in the ideal case where there is no spreading or turbidity. In an actual emulsion, in the case of a line or star image, spreading begins before any relatively high density is reached, so that before a fine line can outline itself with sufficient distinctness, spreading has commenced, filling in the space between the two close lying lines to a greater or less extent, thus limiting the resolving power which can be attained."

In applying these results astronomically due account must be taken of the optical "turbidity" of the image, due largely to atmospheric unsteadiness and dispersion, which generally completely overshadows the inherent turbidity of the emulsion so that the gamma or contrast property of the plate becomes the predominant factor in sharpness and resolving power. Plates of high contrast will give the best results and the apparent contradiction to the laboratory result of greatest sharpness with low wave length, by the astronomical effect of increased sharpness in the star images by the use of an orthochromatic plate and a yellow screen, is explained by the lower contrast of all plates in the violet and by the smaller atmospheric dispersion of the yellow light.

The general demand of astronomers for a high speed plate of fine grain is shown to be scarcely justified as the best linear resolution of double stars with large telescopes is only one-third of that obtainable in the laboratory with high speed emulsions of coarse grain. The author believes that an increase in speed will be of more value in increasing the effective resolving power of a telescope than an increase in the resolving power of the emulsion or in the fineness of the grain. While this may be true in direct photographs of stars, the reviewer believes that, in photographing stellar spectra where the atmospheric turbidity is removed by the slit, an increase in resolving power of the plate is highly desirable. There is no question that visual resolution with the average length of spectroscope camera desirable or possible is very much higher than the photographic.

This paper is a valuable contribution to a difficult and apparently little understood subject. J. S. P.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

THE HILL OBSERVATORY

In the present issue Professor Satterly gives an interesting account of the life and work—especially the educational work—of Sir Norman Lockyer. There has recently come to hand an extract from the *Transactions of the Devonshire Association for the Advancement of Science, Literature and Art*, giving a description of the observatory recently established at Salcombe Regis, Devon, under the name of the Hill Observatory.

It was started privately in 1913 by Sir Norman Lockyer and Lieut.-Col. McClean, but in 1916 was formed into a corporation. The site for the observatory was presented by Sir Norman and Lady Lockyer. It is near Sidmouth and is at an elevation of 560 feet. It is distant from artificial illumination and the meteorological conditions are very favourable. At present there are six buildings, one being a laboratory 104 x 21 feet. Included in the equipment is a 21-inch siderostat; twin telescopes of 12-inch and 10-inch apertures on an equatorial mounting (the former being fitted with a 12-inch prism of 20° angle); twin telescopes of 10-inch and 9-inch apertures, equatorially mounted (the latter having a prismatic camera); wireless apparatus for time and weather signals; and a good research library.

The routine work of the observatory consists in photographing the spectra of stars and classifying them according to temperature and chemical composition; spectroscopic determination of parallax (Adams's method), and other spectroscopic work. An advisory research committee contains the well-known names of Dyson, Eddington, Fowler and Turner.

Best wishes are extended for the success of the institution, but one feels that the observatory should bear the name of Lockyer rather than the colourless and modest name given to it.

C. A. C.

The Royal Astronomical Society of Canada

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